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Frequencies of drought at Ranchi regions, Jharkhand

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सार – इस शोध–पत्र में राँची के 35 वर्षों (1970-2004) के जलवायु संबंधी आँकडों का उपयोग करते हुए जल संतुलन के अध्ययन किए गए है। राँची की वार्षिक जल की आवश्यकता 1754 मि.मी., वर्षा 1460 मि.मी., वास्तविक वाष्पन वाष्पोत्सर्जन 860 मि.मी., जल अधिकता (डब्ल्यू.एस.) 600 मि. मी. और जल की कमी 894 मि.मी. है इस क्षेत्र में पड़े सूखे की बारम्बारता का निर्धारण करने के लिए शुष्कता सूचकांक मानों का विश्लेषण किया गया है। इस अध्ययन से पता चला है कि उक्त अवधि में राँची में बहुत अधिक सूखा और अत्यधिक सूखे का 11 प्रतिशत सूखा पडा किन्तु 35 वर्षों में भयंकर सूखे का केवल 3 प्रतिशत सूखा पडा। मध्यम सूखा श्रेणी 23 प्रतिशत की संभाव्यता सहित सबसे अधिक सामान्य पाई गई है इन अवधियों के विश्लेषण से सम्बद्ध सूखे से यह पता चला है कि वर्ष 1980-84 और वर्ष 1995-99 के पाँच वर्षों की अवधि में मध्यम, बहुत अधिक और भयंकर सूखा पडा है।

ABSTRACT. Studies of water balance have been carried out for Ranchi taking 35 years (1970-2004) of climate data. Ranchi has annual water need of 1754 mm, rainfall of 1460 mm, actual evapotranspiration (AE) of 860 mm, water surplus (WS) of 600 mm and water deficit (WD) of 894 mm. The aridity index values were analyzed to assess the frequency of drought experienced of this region. The study reveals that during the above period, Ranchi has experienced 11 percent of large drought and severe drought, but only 3 per cent disastrous droughts in 35 years. Moderate drought category is observed to be most common with 23 per cent probability. Analyses of periods will contagious drought indicate that during the five year period 1980-84 and 1995-99, moderate, large and severe droughts were experienced.

Key words – Water balance, Water deficit, PET and Aridity index.

1. Introduction

The climatic water balance technique is an unique tool to assess the agroclimatic potential of any region (Pandey and Sheikh 1999). The water balance of an area is an itemised statement of all gains, losses and changes of storage of water occurring in a given area within specified boundaries during a specified period of time. Knowledge of water balance is necessary to evaluate the possible periods of water surplus and water deficit and there in parts on plant growth and productivity besides helping in identifying the possible methods to minimize loss and to maximize gain. Utilization of water, which is so often the limiting factor in crop production could be effectively managed through better understanding of the water balance components in relation to plant water needs.

An approach to study in the climatic water balance was first enunciated by (Thornthwaite and Mather 1948) and later modified by (Thornthwaite and Mather1955). This water balance approach was applied by (Subrahmanyam *et al.,* 1970) for assessing the potential of Godavari river basin. They computed water surplus, water deficit and actual evapotranspiration for the entire basin by utilizing the precipitation and temperature data of 56 stations in the region. Similar study was carried out by (Nale and Correia 1985), who carried out weekly water balance of Udaipur region for individual years during 1977-1981.

As far as agricultural productivity is concerned study of droughts is very important as it helps in planning short-term agricultural operations more efficiently. According

TABLE 1

Mean weekly climatic water balance at Ranchi (1970-2004)

Weeks	PPT (mm)	PET (mm)	SM (mm)	AET (mm)	SPL (mm)	RO (mm)	DEF (mm)	AET/PET
1	1.9	23.8	1.0	2.1	0.0	0.0	21.7	0.09
2	2.6	24.4	0.9	2.7	0.0	0.0	21.7	0.11
3	4.7	25.3	0.8	4.8	0.0	0.0	20.5	0.19
4	7.2	27.1	0.7	7.3	0.0	0.0	19.8	0.27
5	4.7	28.8	0.7	4.7	0.0	0.0	24.2	0.16
6	9.0	30.6	0.7	9.0	0.0	0.0	21.6	0.30
7	8.6	32.4	0.7	8.6	0.0	0.0	23.8	0.26
8	4.8	34.7	0.9	4.6	0.0	0.0	30.1	0.13
9	8.5	36.7	1.0	8.4	0.0	0.0	28.2	0.23
10	4.6	38.7	1.2	4.4	0.0	0.0	34.3	0.11
11	4.2	40.7	1.4	4.0	0.0	0.0	36.7	0.10
12	4.6	42.0	1.5	4.5	0.0	0.0	37.6	0.11
13	7.7	43.2	1.5	7.7	0.0	0.0	35.5	0.18
14	3.9	44.4	1.7	3.7	0.0	0.0	40.7	0.08
15	3.6	45.6	1.9	3.4	0.0	0.0	42.2	0.08
16	7.7	46.8	1.8	7.8	0.0	0.0	39.1	0.17
17	8.2	47.4	1.8	8.2	0.0	0.0	39.2	0.17
18	7.9	48.3	1.8	7.9	0.0	0.0	40.4	0.16
19	9.6	49.1	1.8	9.6	0.0	0.0	39.4	0.20
20	16.0	49.9	1.6	16.2	0.0	0.0	33.7	0.32
21	16.9	48.6	1.4	17.1	0.0	0.0	31.6	0.35
22	12.0	47.7	1.5	12.0	0.0	0.0	35.8	0.25
23	29.9	46.8	1.2	30.2	0.0	0.0	16.6	0.64
24	39.6	46.0	1.0	39.7	0.0	0.0	6.2	0.87
25	80.1	43.0	38.1	43.0	0.0	0.0	0.0	1.00
26	89.1	39.7	50.0	39.7	37.5	18.8	0.0	1.00
27	69.9	36.4	50.0	36.4	33.5	26.1	0.0	1.00
28	87.7	33.1	50.0	33.1	54.6	40.4	0.0	1.00
29	90.4	29.8	50.0	29.8	60.6	50.5	0.0	1.00
30	94.6	31.3	50.0	31.3	63.3	56.9	0.0	1.00
31	81.3	31.1	50.0	31.1	50.2	53.5	0.0	1.00
32	67.5	30.8	50.0	30.8	36.7	45.1	0.0	1.00
33	81.1	30.6	50.0	30.6	50.5	47.8	0.0	1.00

TABLE 1 (*Contd.*)

Weeks	PPT (mm)	PET (mm)	SM (mm)	AET (mm)	SPL (mm)	RO (mm)	DEF (mm)	AET/PET
34	61.2	30.0	50.0	30.0	31.3	39.5	0.0	1.00
35	75.2	29.3	50.0	29.3	45.9	42.7	0.0	1.00
36	79.0	28.7	50.0	28.7	50.3	46.5	0.0	1.00
37	70.5	28.0	50.0	28.0	42.5	44.5	0.0	1.00
38	58.7	27.9	50.0	27.9	30.8	37.7	0.0	1.00
39	39.1	27.9	50.0	27.9	11.2	24.5	0.0	1.00
40	25.1	27.9	47.3	27.8	0.0	12.2	0.1	1.00
41	21.0	27.9	41.2	27.1	0.0	6.1	0.8	0.97
42	17.4	27.9	33.4	25.2	0.0	3.1	2.7	0.90
43	10.8	26.8	24.2	19.9	0.0	1.5	6.9	0.74
44	6.9	26.0	16.6	14.5	0.0	0.8	11.5	0.56
45	4.9	25.1	11.2	10.3	0.0	0.4	14.8	0.41
46	2.8	24.3	7.5	6.5	0.0	0.2	17.7	0.27
47	3.7	23.8	5.2	6.0	0.0	0.1	17.8	0.25
48	3.3	23.3	3.6	4.8	0.0	0.0	18.5	0.21
49	0.3	22.9	2.5	1.4	0.0	0.0	21.5	0.06
50	2.3	22.4	1.9	3.0	0.0	0.0	19.4	0.13
51	2.0	22.6	1.4	2.4	0.0	0.0	20.2	0.11
52	5.0	26.5	1.2	5.3	0.0	0.0	21.2	0.20
	1460	1754		860	600	600	894	

to Thornthwaite and Mather (1955) drought is a situation in which the amount of water needed for potential evapotranspiration exceeds the amount available from precipitation and from the soil. However, plants can with stand moisture stress upto 50 percent of its potential need (AE/PE) beyond which the stress can reduce plants yields significantly.

In the present study the water balance of Ranchi for individual years from 1970 to 2004 have been computed. The drought periods for the above place have been categorized and pentinnial frequency of drought occurrence has been determined.

2. Material & methods

Ranchi experiences tropical climate where the mean rainfall is 1460 mm and 65 % of it is received during monsoon months of June to September. The normal weekly rainfall and potential evapotranspiration (Rao, *et al.,* 1971) were utilized to work out the water balance components.

Daily rainfall data were collected for a period of 35 years from 1970 to 2004 from the Department of Agriculture, Physics & Meteorology, (Birsa Agricultural University), Ranchi. The weekly water balance computations were done for individual years following of (Thornthwaite and Mather, 1955) method to estimate the elements of water balance; *viz*., actual evapotranspiration (AE), water surplus (WS) and water deficit (WD).

For the study of drought with reference to their intensity and frequency, the aridity index (Ia) of Thornthwaite has been found to be a very useful

TABLE 2

Yearly aridity indices at Ranchi

Years	Ia (Aridity Index) = DEF/PET*100	Departure (%)	Years	Ia (Aridity Index) = DEF/PET*100	Departure (%)
1970	63	13	1988	56	0
1971	49	-12	1989	54	-4
1972	64	14	1990	48	-14
1973	53	-5	1991	49	-12
1974	63	12	1992	58	3
1975	56	-1	1993	55	-3
1976	61	9	1994	56	-1
1977	54	-4	1995	57	3
1978	54	-3	1996	59	5
1979	65	15	1997	52	-8
1980	57	2	1998	49	-13
1981	53	-6	1999	56	1
1982	59	5	2000	59	6
1983	60	7	2001	57	1
1984	59	6	2002	57	1
1985	51	-8	2003	54	-4
1986	49	-12	2004	58	4
1987	52	-8			

Note : Median values of Ia : 56
Standard deviation : 4

TABLE 3

Categorization of drought years based upon Aridity index (Ia) based on data for 1970-2004 at Ranchi region

Years	1/2α	1/2α to α	α to 2α	> 2α
	Moderate	Large	Severe	Disastrous
1970-74			3	
1975-79	1		1	1
1980-84	1	3		
1985-89	0			
1990-94	1			
1995-99	2	1		
2000-04	3			
Total	8	4	4	1
% of Drought	23	11	11	3

parameters (Subrahmanyam and Subramaniam 1965 and Subrahmanyam, 1982). Utilizing this method, the years of drought were identified and their intensities were assessed through a study of the departure of the Ia from the median value, following (Subrahmanyam, 1982 and Singh, 2005)

Categorization of Drought	
Departure of the Ia	
From the median value	*Drought intensity*
Less than ½ σ	moderate
½ σ to σ	large
σ to 2 σ	severe
Greater than 2 σ	disastrous
(σ indicates standard deviation)	

Ia = Aridity index, being the percentage ratio of the total annual water deficit (WD) to the total annual water need (WN).

3. Results and discussion

Available water holding capacity for the soils of Ranchi region was assumed as 200 mm. Result of the climatic water balance of Ranchi in the Jharkhand state (Table 1) show that the highest mean weekly rainfall is 94.4 mm occurring in the 30th week. The weekly water surplus is 11 mm to 63 mm in the major crop growing weeks from 26th to 39th. Again it is revealed that on annual basis potential evapotranspiration (PE) exceeds precipitation (P) and the total annual water deficit during the year on average comes to 893.6 mm.

The weekly water balance indicates that the total annual water surplus to be 600 mm. Out of 52 weeks, only 14th are water surplus weeks, which help in recharging the soil profile moisture as well as provide deep drainage (when soil moisture storage exceeds water holding capacity of the soil). In the rest of the weeks there is water deficit. On an annual basis the area has a water need (PET) of 1754 mm, where as the rainfall (P) is 1460 mm and actual evapotranspiration (AET) is 860 mm.

Annual aridity reached a value of 65 (Table 2) in the disastrous year 1979 with 15 per cent departure from the median value of 56. The departure values show the years 1970, 1972, 1974 and 1976 as experiencing severe drought with aridity index around 64 to 61.

The Characterization of aridity index for Ranchi (Table 3) reveals that, during the period under study, the station experienced 8 moderate, 4 severe and large droughts but only 1 disastrous drought in 35 years.

Pentinnial (five – year periods) frequency of drought is in Table 3 as suggested by (Paul *et al.*, 1999). All the 5 years had experienced drought of different categories. Moderate drought category is the most common with 23 per cent while large and severe droughts are 11 per cent. But the disastrous drought is only 3 per cent in 35 years. During the five year period 1975-79 moderate, severe and disastrous droughts were experienced. Prevalence of moderate drought category is a common feature in all the pentinnial periods considered here.

4. Conclusion

The study reveals that, on mean annual basis, the station has water need of 1754 mm, the rainfall is 1460 mm and actual evapotranspiration is 860 mm, water surplus is 600 mm and water deficit is 894 mm. Out of 52nd week, only 26th week to 39th week are water surplus. For the rest weeks are water deficit and the surplus 14th weeks recharge the soil mass. Since water surplus is in excess of rainfall over the water needs of the atmosphere. The march of aridity index at the station showed occurrence of 8 moderate, 4 severe and large drought and only 1disastrous drought years.

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